Middle East Journal of Agriculture Research
ISSN 2077-4605

Volume : 08 | Issue : 03| July-Sept. | 2019
Pages:776-781

Abscisic acid and sucrose promote fruiting of Red Roomy grapevines under Assiut climatic conditions

Fatma El-Zahraa M. Gouda, [2]Asmaa A. Mohamed and [3]Mokhtar M. Shaaban

[1,3]Pomology Department, Fac. Agric., Assiut University, Assiut, Egypt.
[2]Viticulture Dept., Hort. Res. Inst., Agric. Res. Center, Giza, Egypt.

Received: 20 May 2019 / Accepted 03 July 2019 / Publication date: 15 July 2019

ABSTRACT

A Red Roomy grape cultivar does not reach the commercially acceptable level of red color in hot climates, with negative consequences for the grower. Application of abscisic acid (ABA) and sucrose can be a device for overcoming this problem. A commercial formulation of ProTone, active ingredient of ABA 10%, (150 and 300 ppm) and sucrose (10 and 20%) were applied to Red Roomy at the beginning of veraison in arrange to confirm the impact on harvestable bunches, skin color, chemical characteristics and anthocyanin content. Splashing ABA alone at 150 ppm or combined with sucrose 10% lead to improve the color of the berries and increase the anthocyanin content compared to the control treatment. Sugar content, total soluble solids, titratable acidity and TSS/acid ratio were essentially made strides by the application of either ABA alone or in combination with sucrose. These treatments would subsequently advance prior harvests, lower costs by lessening the number of harvests, and diminish losses due to climatic conditions.

***Keywords*:** Red Roomy, ABA, Sucrose, Berries coloration, Berries quality

Introduction

Grape may be a popular fruit crop around the globe. It may be a demonstrate natural product edit, due to its relevance from both an economic and a cultural point of seeing. Other than its utility within food industry, it is getting to be increasingly imperative as a source of auxiliary metabolites, utilized for illustration in healthcare (Howitz *et al.,* 2003). World developed region committed to grapes come to around 10.5 million hectares produced about 89 million tons (FAO, 2017). In Egypt, grape involves the third rank after citrus and mangoes. It has extraordinary significance and plays a vital part in the agricultural economy. The whole region committed for grape was 199212 feddans, whereas the fruiting area of it was 184254, which created around 1691194 tons concurring to the statistics of the Ministry of Agriculture (2016).

Advancement and consequent maturing of fleshy fruits are complex forms counting major metabolic and structural changes, such as accumulation of pigments, flavor and aroma compounds as well as changes in fruit texture. These forms are controlled by an arrangement of signaling occasions controlled by plant hormones (Osorio *et al.,* 2013; Kumar *et al.,* 2014; Obrucheva, 2014). Destitute coloration considerably reduces the economic value of table grapes and this can be a genuine issue in warm developing districts (Winkler *et al.,* 1974). The advancement of color within the berry skin is influenced by a few variables such as diurnal temperature, light intensity, berry quality, leaf surface area, shoot length, carbohydrates, mineral nutrition and plant hormones (Wheeler *et al.,* 2009; Jia *et al.,* 2011).

In Egypt, particularly the Assiut region, the anomaly of the coloring of the Red Roomy grapevine is one of the most issues confronting the promoting of such cultivar. As prove by later inquire about reports in grapes, anthocyanin accumulation begins at veraison stage (onset of ripening). This amassing shows up to be directed by the plant hormone abscisic acid (Ban *et al.,* 2003; Cantin *et al.,* 2007; Lund *et al.,* 2008; Sandhu *et al.,* 2011) and exogenous applications of ABA expanded the anthocyanin content of grape skins (Peppi *et al.,* 2007; Amiri *et al.,* 2010; Gambetta *et al.,* 2010).

There are different signaling pathways related to fruit ripening, and in expansion, we have appeared that sucrose moreover acts as a signal involved in fruit ripening (Jia *et al.,* 2013). It is known to be an activator of gene expression of enzymes involved in anthocyanin biosynthesis (Hiratsuka *et al.,* 2001), and lack of sugar can delay pigmentation of natural products (Telef *et al.,* 2006).

Corresponding Author: Mokhtar M. Shaaban, Pomology Department, Faculty of Agriculture, Assiut University Assiut 71526, Egypt. E-mail: mokhshaaban68@hotmail.com

Moreover, there's persuading prove that ABA and sugar can improve physio-chemical properties of grape berries such as berry weight and volume, fruit firmness, TSS and repress the acidity (Ferrara *et al.,* 2015; Castellarin *et al.,* 2016; Abdel-Aal *et al.,* 2017; Jia *et al,* 2017; Olivares *et al.,* 2017; Farag, *et al.,* 2018; Ramirez *et al.,* 2018; Mohamed *et al.,* 2019).

Based on the above, the display thinks about was conducted to assess the impact of abscisic acid (ABA) and sucrose on yield, anthocyanins and other grape berry quality parameters of Red Roomy grapevines.

Materials and Methods

Plant materials and treatments

This study was carried out amid the two consecutive seasons 2017 and 2018 on fifty-four uniform Red Roomy grapevines grown in a private vineyard found at Sahel Salim area, Assiut Governorate. Vines were 10 years old at the starting of the experiment and planted at 2 x 2.5 m apart. Head pruning system was connected by leaving a total bud load of 49 buds/vine for all the selected vines (13 fruiting spurs x 3 eyes plus five replacement spurs x 2 eyes/vine). Winter pruning was conducted at the second week of Jan. amid both seasons. The chosen vines got the same horticultural practices that were already applied in the vineyard.

Nine cluster splashing treatments of ProTone (active ingredient of ABA 10%) and sucrose were applied as follows: T1 (ProTone 150 ppm), T2 (ProTone 300 ppm), T3 (sucrose 10%), T4 (sucrose 20%), T5 (ProTone 150 ppm + sucrose 10%), T6 (ProTone 300 ppm + sucrose 10%), T7 (ProTone 150 ppm + sucrose 20%), T§ (ProTone 300 ppm + sucrose 20%) and T9 (control, water only). The clusters were sprayed once at veraison stage until runoff, when approximately 10% of the berries on 50% of the clusters had softened. Triton B at 0.1% as a wetting agent was utilized. During both seasons, the following parameters were recorded:

Yield and berry quality

At harvest date cluster weight, the total yield as kg/vine and the weight of 25 berries were recorded. Berry chemical quality in terms of total soluble solids (TSS) was elevated using hand refractometer, Percentage of reducing sugar contents in juice was estimated agreeing to A.O.A.C. (2000) and titratable acidity (TA) was estimated by direct titration with 0.1N NaOH utilizing phenolphthalein as an indicator and expressed as mg tartaric acid per 100 ml juice concurring to A.O.A.C (2000). Berries coloration percentage and total anthocyanin (mg/g), using Ethyl alcohol and HCl at 85:15, was determined using spectrophotometer at wave length 532 (Markham, 1982).

Statistical analysis

The experiment was laid out in complete randomized design (CRD) counting nine treatments and three replicates with two vines for each. The obtained data was subjected to the analysis of variances according to Mead *et al.* (1993). Means separation was made according to the Least Significant Differences (LSD) at 5% level of the probability.

Results

Yield components

Data clear that splashing clusters with ABA or sucrose alone or in combination had no significant effect on the total yield/vine, cluster weight and berry weight (Table 1). However, the best coefficient treatments in their effect on the total yield/vine were splashing sucrose 10% and ProTone 300 ppm + sucrose 20% (10.3 kg), while splashing ProTone 150 ppm + sucrose 20% the most elevated value of the cluster weight (416.0 g) as an average of the two seasons. The outcomes took a similar trend during the two examined seasons.

Berry quality

The perusal of data in Table-2, 3 illustrated that all treatments, whether splashed ProTone and sucrose alone or combined, actuated a significant enhance effect on berry quality compared to the control for the two progressive seasons. Also, data appeared that the splashing ProTone independently or combined with sucrose were better than another treatments.

Table 1: ProTone and sucrose effect on yield/vine, cluster weight and berry weight of Red Roomy grapevines during 2017 and 2018 seasons.

Character	Yield/vine (kg)			Cluster weight (g)			25 berries weight (g)		
Treatment	**2017**	**2018**	**Mean**	**2017**	**2018**	**Mean**	**2017**	**2018**	**Mean**
ProTone 150 ppm	8.9	11.3	10.1	392.8	422.4	407.6	155.6	160.5	158.1
ProTone 300 ppm	9.2	11.2	10.2	396.7	416.2	406.5	158.1	163.7	160.9
Sucrose 10%	9.2	11.4	10.3	392.2	413.3	403.0	153.2	158.8	156.0
Sucrose 20%	9.1	11.0	10.0	391.5	416.4	404.0	153.6	162.5	158.1
ProTone 150 ppm + sucrose 10%	9.0	11.1	10.0	402.9	420.2	411.6	158.9	165.4	162.1
ProTone 300 ppm + sucrose 10%	8.3	11.2	9.8	406.8	418.8	412.8	160.3	166.3	163.3
ProTone 150 ppm + sucrose 20%	9.1	11.3	10.2	405.3	426.3	416.0	158.5	163.8	161.2
ProTone 300 ppm + sucrose 20%	9.2	11.4	10.3	398.5	423.8	411.2	158.9	163.1	161.0
Control	9.0	11.1	10.1	388.3	411.9	400.1	153.3	163.1	158.2
LSD 5%		N.S		N.S	N.S		N.S	N.S	

Table 2: ProTone and sucrose effect on TSS, acidity and TSS/acid ratio of Red Roomy grapevines during 2017 and 2018 seasons.

Character	TSS %			Acidity %			TSS/acid ratio		
Treatment	**2017**	**2018**	**Mean**	**2017**	**2018**	**Mean**	**2017**	**2018**	**Mean**
ProTone 150 ppm	17.76	18.36	18.06	0.36	0.36	0.36	49.45	50.58	50.02
ProTone 300 ppm	17.90	18.18	18.04	0.35	0.36	0.36	50.96	50.50	50.73
Sucrose 10%	17.16	17.60	17.38	0.37	0.38	0.38	46.61	45.95	46.28
Sucrose 20%	17.11	17.82	17.47	0.36	0.38	0.37	47.00	46.90	46.95
ProTone 150 ppm + sucrose 10%	18.08	18.41	18.25	0.35	0.36	0.36	51.20	51.42	51.31
ProTone 300 ppm + sucrose 10%	17.83	18.35	18.09	0.35	0.36	0.36	50.63	50.69	50.66
ProTone 150 ppm + sucrose 20%	18.10	18.60	18.35	0.35	0.36	0.36	51.85	51.52	51.69
ProTone 300 ppm + sucrose 20%	17.83	18.26	18.05	0.35	0.36	0.36	50.83	51.00	50.92
Control	16.83	16.52	16.70	0.39	0.41	0.40	41.97	40.39	41.18
LSD 5%	0.53	0.46		0.02	0.01		2.26	1.89	

Table 3: ProTone and sucrose effect on reducing sugars, anthocyanin content and coloration % of Red Roomy grapevines during 2017 and 2018 seasons.

Character	Reducing sugars %			Coloration %			Anthocyanin (mg/g)		
Treatment	**2017**	**2018**	**Mean**	**2017**	**2018**	**Mean**	**2017**	**2018**	**Mean**
ProTone 150 ppm	14.39	13.88	14.13	75.22	76.47	75.85	2.08	2.12	2.10
ProTone 300 ppm	14.33	13.75	14.04	75.13	75.88	75.51	2.15	2.18	2.17
Sucrose 10%	13.86	13.80	13.83	69.64	71.15	70.39	1.95	2.01	1.98
Sucrose 20%	13.79	13.63	13.71	70.60	72.26	71.43	2.00	2.02	2.01
ProTone 150 ppm + sucrose 10%	14.29	13.69	13.99	76.59	77.65	77.12	2.22	2.22	2.22
ProTone 300 ppm + sucrose 10%	14.35	14.16	14.26	76.10	77.83	76.96	2.16	2.21	2.19
ProTone 150 ppm + sucrose 20%	14.33	13.88	14.11	77.10	78.15	77.63	2.23	2.25	2.24
ProTone 300 ppm + sucrose 20%	14.38	13.63	14.01	76.93	78.53	77.73	2.22	2.25	2.24
Control	13.21	13.10	13.16	67.5	69.10	68.30	1.78	1.84	1.81
LSD 5%	0.63	0.48		3.25	2.95		0.06	0.07	

The best results of TSS 18.35%, TSS/acid ratio 51.69 and the anthocyanin content in the berry skin 2.24 mg/g, as an average of the two examined seasons, were recorded due to spray with combined application of ProTone 150 ppm + sucrose 20% with an increment of 12.85, 25.52 and 23.76%, respectively over the control which recorded the least values of all the studied berry quality.

Likewise, the most elevated value of reducing sugars 14.26% was recorded to splashing ProTone 300 ppm +sucrose 10% with an increment 8.36% over the control.

Moreover, no significant differences were found between splashing ABA alone or combined with sucrose at any concentration. So, it be concluded from economic point of view that splashing ABA alone at 150 ppm or combined with sucrose 10% lead to improve the quantity of Red Roomy berries.

Discussion

Application of a plant growth regulator is one technique for controlling berry quality and skin color development in grape berries. In our comes about, splashing ABA either alone at 150 ppm or combined with sucrose 10% lead to improve the amount of Red Roomy berries and increment total anthocyanin content. A central role for the plant hormone ABA in stimulating fruit ripening has been illustrated amid later a long time. Exogenous application of ABA has been appeared in numerous studies to progress particularly non-climacteric fruit ripening and the related anthocyanin accumulation in grape berries (Wheeler *et al,* 2009; Koyama *et al.,* 2014; Villalobos-Gonzalez *et al.,* 2016; Farag *et al.,* 2018).

The impact of ABA in improving development of berries may be ascribed to its impact as a main signal, activating the onset of the secondary metabolism in grape skin. This result may be due to the uptake of both water and sugar and the augmentation in endogenous levels of ABA. Comparative comes about were expressed by Peppi *et al.,* (2007) and, Leng *et al.,* (2014) who presented that abscisic acid may control berry composition instead of fruit development.

Fruit coloration is due to the presence of different pigments such as chlorophylls, carotenoids and anthocyanins. The red color of the berry skin could be a consequence of anthocyanin biosynthesis and aggregation within the cells (Yamane *et al.,* 2006). These comes about are in concordance with those gotten by (Boselli *et al.,* 2004) who expressed that ABA may increment the anthocyanin content in grape skin and application of ABA might significantly augment the color property of grapes. It was moreover detailed that abscisic acid hastens the initiation of sugar accumulation, by stimulating the uptake and storage of sugars by berries (Davies and Bottcher, 2009). Interests, (Gambetta *et al.,* 2010; Castellarin *et al.,* 2016; Murcia, 2016) found that anthocyanin biosynthesis in grape berries requires increments in sugar concentration.

The utilize of ABA + sucrose progressed fruit quality by expanding the intensity and development of color; these treatments would, subsequently, promote prior harvests, lower costs by decreasing the number of harvests, and diminish damages due to climatic conditions. In fruit ripening, the relationship between ABA and sugar accumulation and turgor pressure, which together control water uptake and cell extension, might signify an illustration of procured usefulness of ABA in angiosperms (Wheeler *et al.,* 2009; Gambetta *et al.,* 2010). The essential roles of abscisic acid and sucrose splashing on enhancing the biosynthesis and translocation of plant pigments and sugars surly effected on progressing berry quality. Within the current study, the foliar application of ABA 150 ppm plus sucrose 10% caused approximately 11% and 22% increment in berries coloration and anthocyanin content compared to untreated ones. These results are in agreement with those obtained by (Zhang *et al.,* 2009; Ferrara *et al.,* 2015).

Conclusion

It is revealed from the present study that the application of abscisic acid and/or sucrose caused slight effects on the Berry weight. However, it significantly improved the berries quality attributes such as berry color, TSS, TSS/acidity ratio and the total anthocyanin content. Eventually, it is recommended to apply 150 ppm of ABA either alone or combined with 10% sucrose at veraison stage in order to obtain the best results. These treatments would therefore promote earlier harvests, lower costs by reducing the number of harvests, and decrease losses due to climatic conditions.

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